TABLE 4.4.2.1.2-1 UPLINK INTERFERENCE POWER INTO IRIDIUM SATELLITE

Hub Xmtr Power/channel	-5	dBW
Min. Antenna Gain	7	dB
EIRP	2	dBW
Power Bandwidth (18 MHz)	-72.5	dB/Hz
Transmitted Spectral Density/Hub	-70.5	dBW/Hz
Factor for 25 interfering hubs	14	dB
Composite uplink power dBW/Hz		-66.5
Average path loss	189	dB
Average Satellite Ant Gain	28	dB
Total Uplink Interference Power		
Into Satellite	-213	dBW/Hz
Satellite Noise Floor	-197.5	dBW/Hz
Percent added noise to receiver	3%	

4.4.2.1.2.2 Interference from Iridium LEO feeder earth stations to LMDS

Each IRIDIUM Gateway station has low sidelobe 3 meter dishes with power programming of the uplink to mitigate possibility of outages due to high density rain cells between a station and its LEO satellite. Typically the antennas will be mounted on a low building within a radome which places them around 50 feet above the ground close to the elevation of 70 feet planned for the LMDS hub stations. Under these circumstances it is necessary to examine Line of Sight (LOS) radio paths to determine the degree of interference injected into Suite 12 receive terminals using Mode 1 troposphere propagation distances.

Table 4.4.2.1.2.2-1 examines the LOS interference injected into a Suite 12 two-way link. The forward and reverse link budgets are listed in the first two columns. As can be seen, for each climatic area, there is enough transmit power such that a clear air margin is established so that with average rainfall, there is greater than 99% probability they will maintain a minimum C/N of 13 dB for a path link of 4.5 miles. The links are balanced each way for the same margin. At the cells fringe area (9.0 miles) they employ 15 in. antennas to maintain the same link margins.

When a Gateway station transmits, it could straddle one or more of the 30 kHz channels with the probability of interference highest into the hub's return link as the hubs are omni in the azimuthal plane. This interference will vary as it tracks the satellite with the maximum being when the station antenna is at its lowest elevation angle of 9° pointed on a radial to the hub and diminishing as it scans away from the Hub. Slew rates will be on the order of 10 seconds per degree at different radials for each satellite pass making for potentially long interference events.

In columns 3 and 4 of Table 4.4.2.1.2.2-1, the average interference power from a Gateway into a Hub or subscriber receiver is calculated for the two cases of minimum uplink power in clear air and maximum through a rain cell. The distance was set to 20 miles which is about the maximum LOS distance between two stations elevated 70 feet above the round. Even with this much separation, the Hub receiver's C/N would be degraded 11.8 dB eliminating any rain margin when the Gateway is transmitting maximum power. If the Gateway was at minimum power the link would be only slightly degraded.

This indicates that the Suite 12 and IRIDIUM gateway stations could not possibly co-share frequencies (same geographic area) where LOS conditions prevail between the stations and the cellular network. Tropo or Mode (1) propagation works poorly at these frequencies so physical terrain isolation is a possibility but difficult to estimate. Site shielding of Gateway terminals would be impractical because of the low elevation coverage and requirement to scan 360. Thus to share, it would be necessary to have greater than LOS separation.

In Table 4.4.2.1.2.2-2 the possibility of interference into the users video receiver. The Gateway must intercept the narrow user beam to affect the received C/N. However, this link is more susceptible because of its larger noise bandwidth and higher gain antenna. However, it is less likely to encounter a beam to beam coupling due to the narrowness of both beams, but when such an encounter occurs there could be a complete outage of the users video channel for up to 10 seconds (i.e. tracking slew rates are 10 seconds per degree).

4.4.2.1.2.3 Allocation Co-existance

As a consequence of the interfering situations described above it is recommended that the best way for the IRIDIUM earth stations to co-exist with the proposed LMDS is to exclude LMDS from the 200 MHz portion of the FSS allocation (29.1 - 29.3 GHz).

Table 4.4.2.1.2.2-1

Interference Into Suite 12 LMDS Two Way

Two-way Links for Los Angeles	Hub-User	User-Hub	7.5 dish Gateway Uplink into Cell Hub	
	Forward	Reverse	Clear	Rain
Freq	28.0	28.0	29.4	29.4
Xmtr Pwr (dBW/3 MHz)			-11.8	13.0
Xmtr Pwr (dBm/30 kHz)	-2.0	-2.0	-1.8	23.0
Ant feed Loss (dB)	1.0	1.0	1.0	1.0
Xmtr Ant Gain (dBi)	10.0	32.0	5.1	5.1
EIRP (dBm)	9.0	31.0	4.3	29.1
Path Length (miles)	4.5	4.5	20.0	20.0
Space loss @ 28 GHz (dB)	138.6	138.6	152.0	152.0
Recvr Ant Gain (dBi)	32.0	10.0	10.0	10.0
Received Carrier Power (dBm)	-97.6	-97.6	-137.6	-112.8
k(dBm/K/Hz)	-198.6	-198.6	-198.6	-198.6
Bandwidth: 30 kHz (dB-Hz)	44.8	44.8	44.8	44.8
Receiver Temp (dB-K)	29.5	29.5	29.5	29.5
Receiver Noise Pwr (dBm)	-124.3	-124.3	-124.3	-124.3
		-124.1	-112.5	
C/N (dB)	26.7	26.7	26.5	14.9
Min. C/N Reqd	13.0	13.0	13.0	13.0
Rain Margin (dB)	13.7	13.7	13.5	1.9

Table 4.4.2.1.2.2-2

Interference Into Suite 12 LMDS Two Way Link

Video Link for Los Angeles 7.5 in dish

	Hub-User	Gateway Uplink into User Terminal Clear	Gateway Uplink into User Terminal Rain	
Freq	28.0	29.4	29.4	
Xmtr Pwr/Channel (dBW/3MHz)	-11.8	-11.8	13.0	
Ant feed Loss (dB)	1.0	-1.0	-1.0	
Xmtr Ant Gain (dBi)	10.0	5.1	5.1	gain 9°
EIRP (dBW)	-0.8	-7.7	17.1	
Path Length (miles)	4.5	20.0	20.0	
Space loss @ 28 GHz (dB)	138.6	152.0	152.0	
Recvr Ant Gain (dBi)	32.0	32.0	32.0	
Recved Power (dBW)	-107.4	-127.6	-102.8	
k (dBW/K/Hz)	-228.6	-228.6	-228.6	
Bandwidth: 18 MHz (dB-Hz)	72.6	72.6	72.6	
Receiver Temp (dB-K)	29.5	29.5	29.5	6 dB NF
Receiver Noise Pwr (dBW)	-126.5	-126.5	-126.5	
IM+Noise (dBW)	-125.9	-123.7	-102.8	N+1
C/N	18.5	16.3	5.2	
Min C/N Reqd	13.0	13.0	13.0	
Rain Margin (dB)	5.5	3.3	-7.8	

4.4.2.1.3 Sharing with the FIXED service

The Iridium LEO satellite employs 29.1-29.3 GHz frequency band for its feeder uplink and therefore must coordinate with FIXED terrestrial networks and FSS(earth-space) in the 27.5-29.5 band. In addition, the LEO satellite receiver with its' antenna pointed to the earth, could suffer interference from FIXED terrestrial networks.

4.4.2.1.3.1 Interference from FS to LEO satellite receivers

Interference into LEO satellite receivers from the fixed service is generally addressed by limits on terrestrial transmitter EIRP and power delivered to the antenna. The first protects satellites from mainbeam interference while the second protects the satellites from the cumulative effect of fixed service transmitter backlobe emissions.

From Article 27 (RR 2505,2508,2511) of the Radio Regulations, maximum EIRP of a station in the FIXED or MOBILE service shall not exceed +55 dBW. In addition, the power delivered by a transmitter to the antenna of a station in the FIXED or MOBILE service in frequency bands above 10 GHz shall not exceed +10 dBW. There is no restriction as to the direction of maximum radiation for stations in the FIXED or MOBILE service above 15 GHz (RR2504)

A LEO's uplink steerable satellite receive antenna continually sweeps the earth's surface projecting near maximum gain over large areas particularly when the earth station antenna is at low elevation angles. Iridium could be as low as 9 degree in the CONUS. If the terrestrial transmitter should have its main beam sited up at this elevation angle, then significant interference would occur with its 55 dBW EIRP as contrasted with the Iridium minimum uplink EIRP of only 43 dBW. In addition, if the terrestrial interferer is geographically close to the LEO earth station, then this interference could last for many seconds depending on the relative ground track of the satellite to the heading of the terrestrial station.

To reduce the interference from a single terrestrial station into Iridium's LEO to below the harmful level it would be necessary to restrict the EIRP radiated from the station at angles of 9° or greater above the horizon. Since Iridium's minimum uplink EIRP is 38.3 dBW/ MHz it would be necessary to set the terrestrial radiation to 38.3-13 or 25.3 dBW/MHz at elevations of 9° or greater. This would reduce the link margin by 0.25 dB for the time of maximum interference. It should be noted that a typical terrestrial station operating with maximum antenna input power of 10 dBW would normally occupy at least a 20 MHz channel bandwidth for an input power to the antenna of -3 dBW/MHz (10 - 13(dB/MHz)). If the terrestrial antenna met a typical sidelobe requirement of 32-25log(phi), then the transmitting station could elevate its antenna to an elevation angle of 8° and still meet the 25.3 dBW/MHz requirement at an elevations of 9° or greater. This sharing with the Fixed service can be accomplished with the indicated limits.

4.4.2.1.3.2 <u>Interference from LEO Earth stations to FS</u>

Coordination between MSS earth station and FIXED service is required as the uplink feeder transmissions could interfere with terrestrial receivers on the co-shared frequency bands. The earth stations operating with LEO's will scan the volume from 9 degree above horizon to 360 degree. in azimuth in order to maintain continuous feeder link transmissions with LEO satellites when they are in the Field of View. There are two modes of propagation which can create interference paths. Mode (1) is a great circle path of tropospheric scatter and Mode (2) is hydrometric scattering from clouds or rain cells. The attenuation constants for these propagation modes is not well understood for frequencies above 15 GHz but values are recommended in Appendix 28.

In Table 4.4.2.1.3-1, the Mode (1) coordination distance over land (Climate Zone: A) was calculated for the Iridium gateway assuming that the uplink was at maximum EIRP and pointed at the minimum elevation angle of 9 degree. As can be seen the coordination distance of 64 km is not much further than line of sight and it is reasonable to coordinate with all terrestrial links within that distance. A interference study would factor in terrain blockage and actual terrestrial receive antenna gain in the radial towards the earth station in order to ascertain whether interference is very probable. A similar calculation for Mode (2) shows that this coordination distance is less than 64 km but a different interference analysis is required.

Table 4.4.2.1.3-1 Mode (1) Coordination Distance for 29 GHz Uplink

Boltzsman _k	1.38E-23	(J/°K)	Climate Zone_x	A	
Bandwidth BW	1.00E+06	(Hz)	Probability p	0.003	
Freq	29.20	(GHz)			
			Rec Noise Te	3200.00	(°K)
			Rec Noise power	-133.55	(dBW)
			J (20% vs. thermal)	0.00	(dB)
			M(p)	30.00	(dB)
			W	0.00	(dB)
Pr(p) Max rec inter	-103.55	dBW	**Iridium Gateway UL**		
			Power Input to Ant	12.00	dBW
			Modulation BW	3.00	MHz
			Interfer xmtr Pt	7.23	dBW/MHz
			Delta gain delta_g	8.00	(dB)
			Angle to Horiz Phi	9.00	(degree)
			Interfer ant Gt	5.14	(dBi)
			Gain to Horiz Gr	50.00	(dBi)
Lb(p) Min. link loss	165.92	(dB)			
			Freq Loss Ao	149.31	(dB)
			Horizon Angle e	0.00	(degree)
			Angle Correct factor Ah	0.00	(dB)
			Atmospher Attn Rate	0.26	(dB/km)
Coordination Dist.	64.23	(km)	Max/Min distance	100 KM	

4.4.2.1.4 Summary of Sharing in the 28.5 - 29.5 GHz Band (Uplink)

The existing and proposed uses of the allocation 28.5 - 29.5 GHz were depicted in Figure 4.4.2-1. The LEO uplink feederlinks of concern are the proposed 200 MHz uplink of the Iridium system at 29.1 - 29.3 GHz. These overlap the spectrum proposed for use by the uplink for the FSS Technology demonstration system ACTS, 28.9-29.8 GHz, and the B-band of the Local Multipoint Distribution

System (LMDS) proposed in a recent FCC NPRM. In addition the band is shared with the Fixed Service.

Analyses were performed for the LEO Earth Station causing and receiving harmful interference with: A) the Fixed Satellite Service (FSS); B) LMDS; and C) the Fixed Service. A summary of the findings in each of these areas is as follows:

A. Sharing with FSS

The occurrence of main beam coupling which could result in mutual adverse interference between the GSO/FSS system and the LEO/FSS networks can be mutually avoided through one or more techniques/ These include: 1) use of band segmentation; 2) the switching of a LEO Earth Station from one LEO satellite receiver to an alternate; 3) Use of Alternate Gateways (via land line); 4) acceptance of short term outages; 5) acceptance of the interference level. In addition, when coordinating the site of the LEO Earth Station with that of the FSS Earth Station an area of geographic isolation (i.e. exclusive geographical service area) can be established within which interference is reduced to acceptable levels.

Most of these options are operational arrangements which may be agreed at the time of licensing and/or coordination if necessary. Several new rules to address the situation are provided in section 5.

B. Sharing with LMDS

The analyses have shown that in major metropolitan areas the LEO Earth Stations would cause unacceptable interference to a LMDS type of implementation, and the LEO satellite receiver would receive unacceptable interference from a group of LMDS transmissions. Therefore, if the LMDS is to be established, it should be excluded from the 200 MHz proposed to be used by Iridium.

C. Sharing with the Fixed Service

It is not clear to what extent the fixed Service will be implemented in the 28.5 - 29.5 GHz band. To some extent sharing criteria either exists or could be developed and existing coordination methods applied to provide for the co-existence of the Fixed and Fixed Satellite services. However, constraints would have to be put on both services particularly close to major cities, and therefore given the amount of spectrum available, a geographic based band segmentation of 200 MHz to accommodate the requirement would be the simplest approach to provide for co-existence with this service.

4.4.2.2 Sharing Issues in the 29.5 - 30.0 GHz Band (Uplink)

In the frequency range 29.5 - 30.5 GHz, which is planned to be used by ODYSSEY for its Earth-to-space feeder link, the only other primary users are FIXED-SATELLITE (full band) and MOBILE-SATELLITE (full band in Region 2; only 29.9 - 30.0 GHz in Regions 1 and 3). This section addresses sharing issues with those two services in the following sections.

4.4.2.2.1 Sharing Issues with the Fixed-Satellite Service (29.5 - 30.0 GHz)

Table 4.4.2.2.1-1 lists the only Fixed-Satellite Service systems in this frequency range that have so far been Advanced Published by the IFRB. The table also indicates whether the system has been simply Advanced Published, Coordinated or Notified (and operational), the orbit location, and the frequency range.

Satellite Name	FRB Status (A, C or N)	Orbit Location(s)	
ACTS	C	100°W	28.970 - 29.975
DFS	C	33.5°E	
	C	26.0°E	
EDRSS	A	44.0°W	27.500 - 30.000
	A	32.0°W	
	A	47.0°E	
	A	59.0°E	
ETS-6-FS	C	154°E	27.500 - 31.000
ITALSAT	N	13.2°E	28.215 - 29.997
GOMS	C	14.0°W	
	C	76.0°E	
	C	166.0°E	
N-STAR	C	132°E	27.500 - 31.000
	C	136°E	

Table 4.4.2.2.1-1

The ODYSSEY feeder link currently requires approximately 100 MHz of bandwidth. At present it is assumed that this will be located at the top of the 500 MHz band (29.5-30.0 GHz). In this case there would appear to be a frequency overlap with all the systems listed in Table 4.4.2.2.1-1.

4.4.2.2.1.1 **Interference from LEO Earth Stations to FSS(GSO) Satellites**

In this case, to prevent harmful interference from the ODYSSEY feeder link earth station transmissions into the FSS GSO systems, several solutions are possible, as follows:

1. Ensure, if it is possible, that the ODYSSEY orbit ground tracks are such that there is never a direct alignment between the ODYSSEY feeder link earth station and the FSS GSO satellite. The current ODYSSEY orbit parameters result in such alignment situations occurring approximately every 6° along the GSO arc. Therefore this solution maybe viable provided the use of common frequency bands by FSS GSO satellites is_very low, as it is at present.

2. Coordinate with the FSS GSO systems such that the alignment does not produce harmful interference into the FSS GSO system. This could be achieved by a combination of the control of power levels and the avoidance of co-frequency operation.

3. Provide ODYSSEY feeder link earth station diversity, so that when an alignment situation might occur with one of the earth stations, a switchover is made to the other earth station, thus avoiding an alignment problem with an operational MSS link.

4.4.2.2.1.2 **Interference from FSS(GSO) Earth Stations to LEO Satellites**

In this case, to prevent harmful interference from the FSS (GSO) earth station transmission into the ODYSSEY satellites, several solutions are possible, as follows:

1. Ensure, if it is possible, that the ODYSSEY orbit ground tracks are such that there is never a direct alignment between the FSS (GSO) earth stations and the active ODYSSEY satellites. Because of the uncertainty in the location of the FSS (GSO) earth stations, this may not be feasible to implement, particularly in comparison with the corresponding measure proposed in section 4.4.2.2.1.1 (Item 1) above.

2. Point the ODYSSEY feeder link steerable satellite antenna to a point on the earth where there are no FSS (GSO) transmitting earth stations. Depending on the characteristics of the FSS(GSO) system, this may or may not be possible.

3. Coordinate with the FSS(GSO) systems such that the alignment does not produce harmful interference into

the LEO system. This could be achieved by a combination of the control of power levels and the avoidance of co-frequency operation.

4.4.2.2.2 **Sharing with the Mobile-Satellite Service (29.5-30.0 GHz)**

The concept of providing MSS at the frequency band is relatively new. Other than ACTS and NORSTAR-I, there are presently no other firm plans for systems. In the event that such systems do come into being, it is important to note that they will not benefit from the extra protection given to FSS GSO systems (RR 2613). Future MSS systems in this band could employ either GSO or LEO satellite constellations, and would need to coordinate with LEO systems.

4.4.2.2.2.1 **Interference from MSS (LEO or GSO) Service Link Earth Stations to LEO Feeder Link.**

Being a mobile service, the MSS service link systems operating in this band will undoubtedly use mobile earth terminals that are small, low powered and which produce a relatively wide beam. This will dictate having relatively high antenna gain on the MSS satellite, and relatively low EIRP radiated by the mobile terminal. There likely characteristics of the MSS service link will tend to minimize the interfering effect of the mobile earth stations into the MSS feeder link.

4.4.2.2.2.2 **Interference from LEO Feeder Link Earth Stations to MSS(LEO or GSO) Satellites (Service Link)**

Interference from the MSS feeder link into the MSS service link will have to be coordinated, based on the specific orbit constellation characteristics of the MSS system which uses this band for its service link. The relatively narrow beamwidths of the MSS feeder link, both in terms of the satellite and earth station antennas, will help in resolving any interference issues.

4.4.2.2.3 **Summary of sharing in the 29.5-30.0 GHz band**

In the frequency band 29.5-30.0 GHz that is planned for use by the ODYSSEY system for its Earth-to-space feeder link, the full 500 MHz is allocated on a co-primary basis to the Fixed-Satellite Service and the Mobile-Satellite Service in Region 2. In Regions 1 and 3, the Mobile-Satellite allocation is co-primary only at 29.9-30.0 GHz (and is secondary at 29.5-29.9 GHz). The ODYSSEY system requires slightly more than 100 MHz of the preferred band, and would be located at the top end of the frequency range.

In order for ODYSSEY to share with geostationary Fixed-Satellite Service systems, there are several steps that could be taken to prevent harmful interference from ODYSSEY earth stations to geostationary FSS satellites. Possible steps include ensuring that ODYSSEY orbit ground tracks are such that there is never a direct alignment between the ODYSSEY earth station and the geostationary FSS, if it is possible, satellite (a solution may be viable when geostationary FSS use of the band remains at its current low levels); coordinating with geostationary FSS systems to mitigate or avoid potential harmful interference from instances of alignment (through control of power levels and avoidance of co-frequency operation); and the use of ODYSSEY feeder link earth station diversity.

Steps can also be taken to prevent harmful interference from geostationary FSS earth stations to ODYSSEY satellites. These steps include attempting to avoid direct alignment between ODYSSEY satellites and the geostationary FSS earth stations; pointing ODYSSEY satellites' steerable antennas to points on the Earth where there are no transmitting geostationary FSS system earth stations; and coordinating with geostationary FSS systems to mitigate or avoid potential harmful interference from instances of alignment (through control of power levels and avoidance of co-frequency operation).

Sharing with the MSS at 29.5-30.0 GHz should be made possible by the fact that there are only two planned systems in the U.S. (ACTS and NORSTAR-I) and no other existing or planned MSS systems in the band, and by the fact that geostationary MSS systems, unlike geostationary FSS systems, do not receive the added protection afforded by RR 2613. Any interference to ODYSSEY from MSS service links in the band will be minimized by the likely characteristics of the mobile earth stations. Interference from ODYSSEY feeder links to MSS service links will have to be coordinated but the relatively narrow beamwidths of the Odyssey feeder link will help resolve any interference issues.

4.4.3 18.8 - 20.2 GHz Downlinks

The downlinks of the 20 GHz LEO Feeder links fall into two parts. Section 4.4.3.1 concerns sharing in the 18.8-19.7 GHz band. Section 4.4.3.2 concerns sharing in the allocation 19.7-20.2. Figure 4.4.3-1 depicts the potential interference situations in the bands.

Users and proposed users of the 18.8 - 20.2 GHz band include downlinks corresponding to the uplinks discussed in section 4.4.2. Typical transmitting space station characteristics for FSS systems are given in Figure 4.4.3-2. Typical receiving Earth station characteristics are given in Figure 4.4.3-3.

The fixed service, as currently allocated within the United States in the 18.8 - 19.7 GHz band would include conventional point-to-point systems. Characteristics of fixed systems are given in Figure 4.4.3-4.

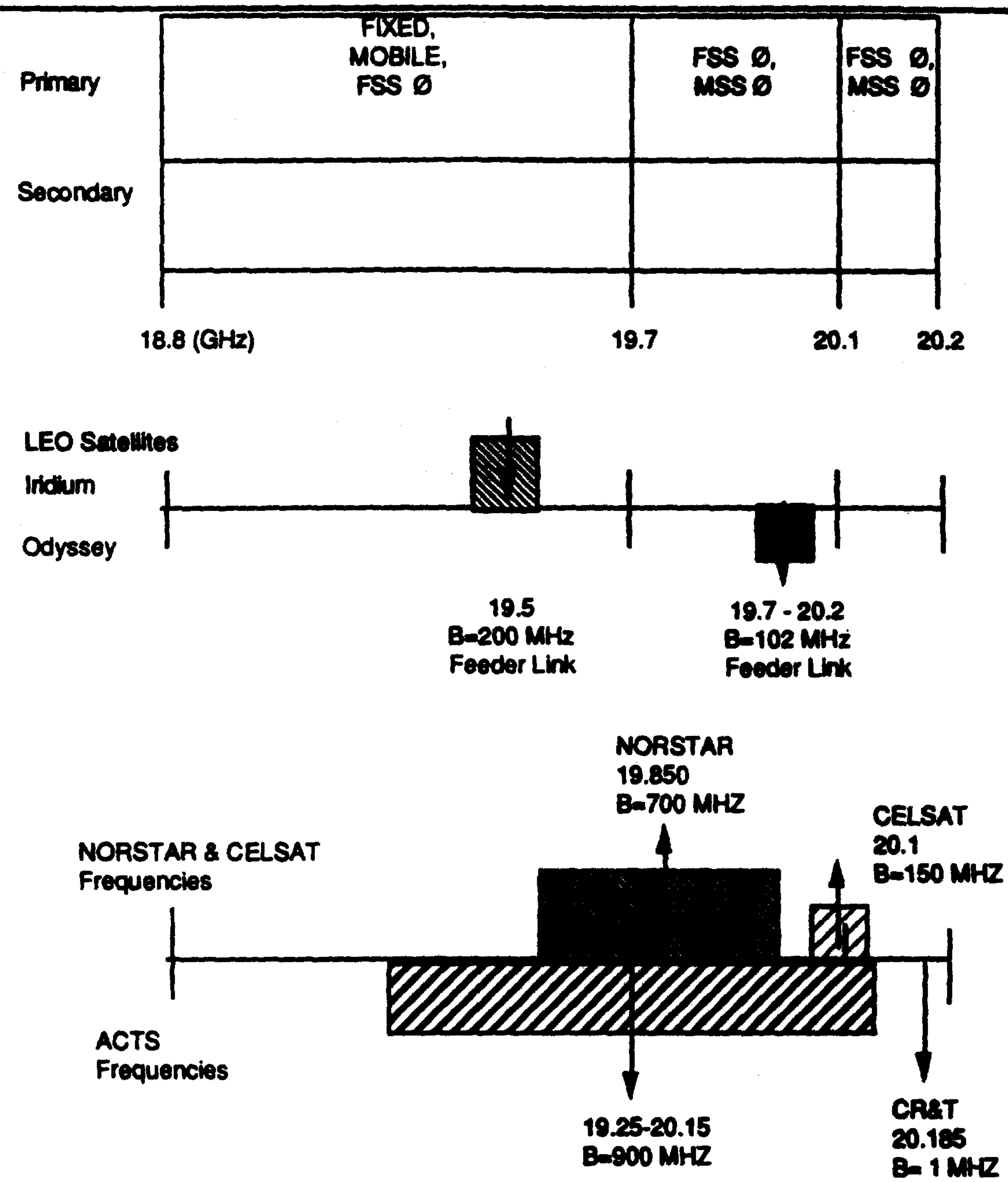


Figure 4.4.3-1. Region 2 allocations and other users of the 19 GHz band

System	Orbit Long	Long Toler	Frequency Band		Polar-zation	ES Type	Ps	G3
GOMS (all)		0.1	20,030.00	20,380.00	-	FSS	-29.6	38.0
ACTS		0.1	19,250.00	20,150.00	-	NGS,LBR	-58.7	53.2
ACTS		0.1	20,184.50	20,185.50	-	CR&T	-67.0	30.8
SARIT	-19.0	0.1	19,700.00	20,200.00	-		-54.0	41.0
L-SAT	-19.0	0.1	18,720.00	19,790.00	-	FSS	-45.0	43.0
LOUTCH-1	-14.0	0.2	19,237.00	19,237.00	LHC	FSS	-42.9	30.0
ITALSAT	13.0	0.1	18,685.00	20,125.00	-	FSS	-54.0	49.5
EDRSS		0.1	18,100.00	20,200.00	-	FSS	-58.0	41.0
ETS-6-FS	154.0	0.5	17,700.00	21,200.00	-	FSS	-57.6	52.0
F-SAT		0.2	19,700.00	20,200.00	-	FSS	-56.0	41.3
DFS		0.1	19,700.00	19,825.00	-	FSS	-55.0	42.3
CS-2A, 2B CS-3A, 3B		0.1	17,770.00	19,452.00	RHC	FSS	-51.6	40.5
APEX	10.0	0.2	19,700.00	20,200.00	-	FSS	-56.0	41.3
SCS-1		0.1	17,770.00	19,452.00	RHC	FSS	-51.6	47.2
SUPERBIRD		0.1	18,490.00	19,447.00	RHC	FSS	-51.6	47.2
NORSTAR I	-90.0	0.05	19,500.00	20,200.00		FSS,LMSS	-7.0	44.7
SKYNET-4		0.1	20,200.00	21,200.00	-	Mobile Sat	-44.0	35.0

Figure 4.4.3-2. Transmitting space station characteristics – 20 GHz band

System	Frequency band		Polar lization	Station Type	G4	Radiation Pattern	Te	Gam ma	Teq
ETS-6-FS	20,001.90	20,365.50	D	FSS	58.2	Rec 465	273	-33.9	163
ETS-6-FS	20,001.90	20,365.50	D	FSS	58.2	Rec 465	273	-47.8	184
ETS-6-FS	20,001.90	20,365.50	D	FSS	58.2	Rec 465	273	-38.8	400
GOMS (all)	20,030.00	20,190.00	RHC	Met-sat	55.0	Rec 465	250		
GOMS (all)	20,030.00	20,380.00	-	FSS	55.0	App 29	1000	-17.5	1050.0
TOR	18,200.00	21,200.00	LHC		51.0	Rec 465	500		
TOR	18,200.00	21,200.00	LHC		43.0	App 29	500		
TOR	18,200.00	21,200.00	LHC		32.0	App 29	500		
ACTS	19,250.00	20,150.00	-	FSS	45.6	App 28	977		
ACTS	19,250.00	20,150.00	-	FSS	57.2	App 28	631		
ACTS	20,184.50	20,185.50	-	FSS	52.0	App 28	977		
SARIT	19,700.00	20,200.00	-		58.2	Rec 465	400	-21.0	410.0
L-SAT	18,720.00	19,790.00	-	FSS	68.0	Rec 465	800	-14.0	900.0
LOUTCH-1	19,237.00	19,237.00	LHC	FSS	45.0	Rec 465	1800		
ITALSAT	18,685.00	20,125.00	-	FSS	58.4	Rec 465	400	-5.5	410.0
EDRSS	18,100.00	20,200.00	-	FSS	41.0	Rec 465	795	-3.1	1620.0
ETS-6-FS	17,700.00	21,200.00	-	FSS	57.5	Rec 465	295	-26.3	337.0
F-SAT	19,700.00	20,200.00	-	FSS	54.3	App 28	590	-12.7	675.0
DFS	19,700.00	19,825.00	-	FSS	50.0	App 29	200	-13.0	250.0
CS-2A, 2B CS-3A, 3B	17,700.00	19,520.00	RHC	FSS	65.7	Rec 465	290	-24.9	298.0
APEX	19,700.00	20,200.00	-	FSS	54.3	App 28	590	-12.7	675.0
SCS-1	17,770.00	19,452.00	RHC	FSS	57.7	Rec 465	250	-13.1	318.0
NORSTAR I	19,500	20,200.00		FSS, LMSS				-4.1	1370
NORSTAR I	19,500	20,200.00		FSS, LMSS				--16.8	841.0
SUPERBIRD	18,490.00	19,447.00	RHC	FSS	57.7	Rec 465	250	-13.1	318.0

Figure 4.4.3-3. Receiving earth station characteristics — 20 GHz band

FREQUENCY BANDS (GHz)	17.7 – 19.7						
MODULATION	QPSK	4QAM	4FSK	QPSK	8PSK	QPSK	O-QPSK
CAPACITY	140Mbit/s	140Mbit/s	8Mbit/s	8Mbit/s	8Mbit/s	34Mbit/s	44.7Mbit/s
CHANNEL SPACING (MHz)	110	55	20	20	20	27.5	40
ANTENNA GAIN [MAX] (dB)	48	48	45	45	45	45	45
FEEDER/MUX LOSS [MIN] (dB)	7	7	0	0	0	0	3
ANTENNA TYPE (TYP)	dish	dish	dish	dish	dish	dish	dish
MAX Tx OUTPUT POWER (dBW)	-10	-4	-16	-6	-9	-8	-9
EIRP [MAX] (dBW)	31	37	29	39	27	37	33
RECEIVER IF BANDWIDTH (MHz)	65	66	48	18	6	18	40
RECEIVER NOISE FIGURE (dB)	7	8	13	7	7	7	5
RECEIVER THERMAL NOISE (dBW)	-119	-118	-122	-131	-128	-124	-125
NOMINAL RX. INPUT LEVEL (dBW)	-63	-64	-65	-65	-65	-65	-70
Rx INPUT LEVEL FOR 10E-3 BER (dBW)	-103	-104	-106	-116	-116	-113	-106
MAX. LONG-TERM INTERFERENCE (dBW)	-129	-131	-132	-141	-138	-143	-131
EQUIVALENT POWER (dBW/4KHz)	-	-	-	-	-		-171
SPECTRAL DENSITY (dBW/MHz)	-147	-149	-141	-147	-147		
MAX, p.f.d. (dB[W/sq m/4KHz])							
REFER TO NOTES	(B), (1)	(B), (1)	(B), (1)	(B), (1)	(B), (1)	(B), (1)	(A)

NOTES

(A) Specified interference will reduce system C/N by 1dB (Interference 6dB below receiver thermal noise floor)
(B) Specified interference will reduce system C/N by 0.6 dB (Interference 10 dB below receiver thermal noise floor)
(1) The specified interference level is total power within the receiver bandwidth

Figure 4.4.3-4. Characteristics of conventional point-to-point systems

4.4.3.1 Sharing in the 18.8-19.7 GHz Band (downlink)

The interference paths of concern in this allocation are:

a. LEO downlink into Fixed service receiver

b. Fixed transmitters into LEO earth station receivers

c. LEO downlink into FSS(GSO) earth station receivers

d. FSS(GSO) satellite transmitters into LEO earth station receivers

The down link feeder link covers the band from 19.4-19.6 GHz and therefore must coordinate with FIXED terrestrial networks, FSS(space-earth), and MOBILE but not Mobile-Satellite service which is above 19.7 GHz.

4.4.3.1.1 Sharing with the Fixed-Satellite Service (18.8-19.7 GHz)

4.4.3.1.1.1 Interference from transmitting LEO satellites to FSS(GSO) earth station receivers

The worst case interference condition occurs when the LEO satellite is in the main beam of the FSS(GSO) earth terminal. This configuration is Case 3 of Figure 4.4.3.1.1.1-1. There is a low probability of this occurrence (see paragraph 4.1.2).

First it must be determined if there is sufficient energy arriving at the FSS(GSO) earth station to cause harmful interference. The maximum flux density incident at a FSS(GSO) earth station due to emissions from a FSS(GSO) satellite can be determined as follows:

Radio regulation PFD at the earth's surface in the beam area is -115 to -105 dBW/m^2/MHz depending on the elevation angle.

This must now be compared to the PFD generated by the LEO

PFD at the earth's surface in the beam area -120.1 dBW/m^2/MHz

Coordination must be performed for the mainbeam to mainbeam situation. However, when tracking antennas are installed on the LEO satellite, areas of geographic isolation can be established. If the resulting level is greater than a non-interference level, an acceptable option to reduce or prevent interference should be exercised.

There are five options available, of which three are common to both cases (c, d and e) :

a) System coordination (case specific)

b) Geographic isolation (case specific)

c) Switching of a LEO Gateway path from one satellite to another

d) Use of an alternate Gateway (via land line)

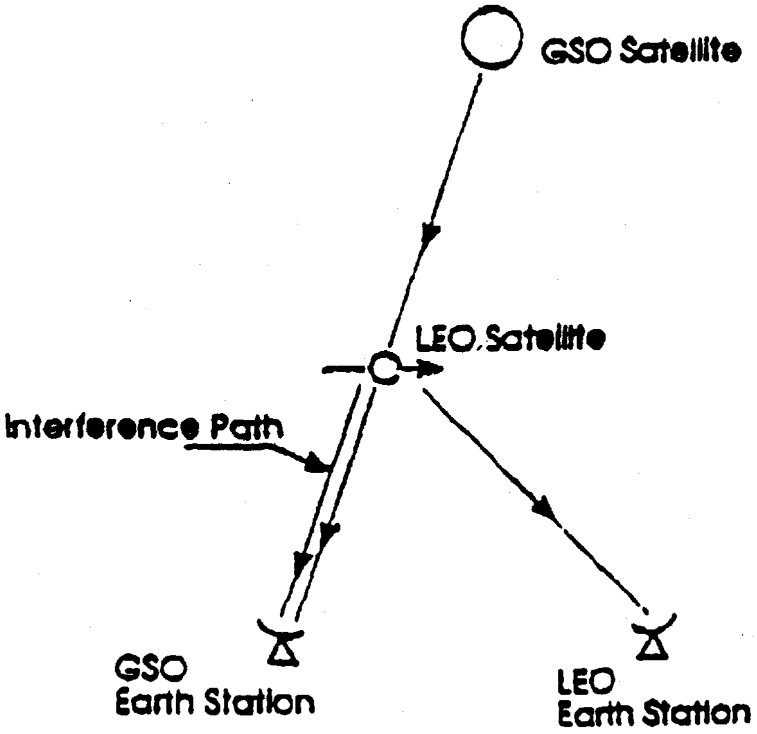
e) Acceptance of short term outages. Options c, d and e are discussed in section 4.4.2.1.1.

Option a):

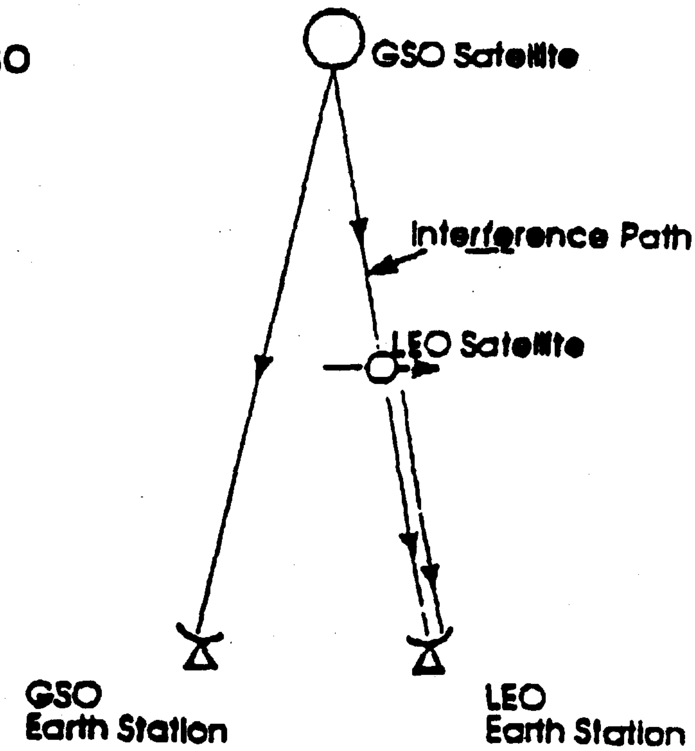
If the degree of interference to the FSS(GSO) system is small enough and short enough, the FSS(GSO) system may tolerate the interference. This should be determined through a coordination process.

Option b):

The signal level into the FSS(GSO) receiver is reduced by the off-axis gain of the satellite antenna. In coordinating the LEO station with existing FSS(GSO) stations, an appropriate geographic isolation area can be determined can be determined. If this area is avoided by FSS(GSO) earth stations, then the required isolation from FSS(GSO) earth station transmissions is achieved. Subsequent FSS(GSO) earth station applications would follow the same procedure.



Downlink LEO Interference into GSO
Case 3



Downlink GSO Interference into LEO
Case 4

Figure 4.4.3.1.1.1-1 Downlink interference cases

4.4.3.1.1.2 Interference from transmitting FSS(GSO) satellites to LEO earth station receivers

Downlink interference to a LEO receiver occurs if a FSS(GSO) satellite projects sufficient energy to cause harmful interference. The worst case condition occurs when the FSS(GSO) satellite is in the main beam of the LEO earth terminal. This configuration is Case 4 shown in Figure 4.4.3.1.1.1-1. There is a low probability of this occurrence (see paragraph 4.1.2).

First it must be determined if there is sufficient energy arriving at the LEO earth station to cause harmful interference. The minimum power flux density incident at a LEO earth station due to emissions from a LEO satellite can be determined as follows:

PFD at the earth's surface in the beam area -134.3 dBW/m^2/MHz

This must now be compared to the PFD generated by the FSS(GSO). The Radio Regulation for maximum PFD at the earth's surface in the beam area is -115 to -105 dBW/m^2/MHz depending on the elevation angle.

The above shows that coordination must be performed for the mainbeam to mainbeam situation. However, when tracking antennas are installed on the LEO satellite, areas of geographic isolation can be established. If the resulting level is greater than a non-interference level, an acceptable option to reduce or prevent interference should be exercised.

There are five options available, of which three are common to both cases (c, d and e) :

a) System coordination (case specific)

b) Geographic isolation (case specific)

c) Switching of a LEO Gateway path from one satellite to another

d) Use of an alternate Gateway (via land line)

e) Acceptance of short term outages.

Options c, d and e are discussed in section 4.4.2.1.1

Option a)

If the degree of interference to the LEO system is small enough and short enough, the LEO system may tolerate the interference. This should be determined through a coordination process.

Option b)

The signal level into the LEO receiver is reduced by the off axis gain of the FSS(GSO) satellite antenna i.e. the FSS(GSO) satellite may employ spot beams. In coordinating the LEO station with existing FSS(GSO) stations, an appropriate separation distance can be determined. This distance must produce an angle that is large enough to provided the required attenuation. Subsequent FSS(GSO) station applications would follow the same procedure.

4.4.3.1.2 LEO Downlink sharing with fixed service (18.8-19.7 GHz)

The down link feeder link covers the band from 19.4-19.6 GHz and therefore must coordinate with FIXED terrestrial networks, FSS(space-earth), and MOBILE but not Mobile-Satellite service which is above 19.7 GHz.

4.4.3.1.2.1 Interference from LEO downlinks into fixed service receivers

Interference into the fixed service from satellite services is generally addressed by limits on the power flux -density of the satellite emissions at the surface of the Earth. From the Radio Regulations (RR 2578).

"the power flux-density at the Earth's surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed:

$-115 dB(W/m^2)$ in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

$-115 + 0.5(\partial - 5)$ $dB(W/m^2)$ in any 1 MHz band for angles of arrival ∂ (in degrees) between 5 and 25 degrees above the horizontal plane;

-105 $dB(W/m^2)$ in any 1 MHz for angles of arrival between 25 and 90 degrees above the horizontal plane.

The pfd levels produced by the Iridium satellite are illustrated in Table 4.4.3.1.2-1. For this calculation the downlink power is assumed to be programmed for the maximum of

23.7 dBWi. As can be seen the downlink PFD easily meets the requirement for all elevation angles with a margin of 10 dB or more for all elevation angles.

Table 4.4.3.1.2-1 Down Link Flux Density

slant range (km)	elev angle (deg)	Spreading (dB)	PFD (dBW/MHz)	limits (dBW/MHz)	Margin (dB)
780	90	-128	-109	-105	4
783	84	-128	-109	-105	4
794	79	-128	-109	-105	4
812	73	-128	-109	-105	4
839	67	-128	-109	-105	4
877	61	-129	-110	-105	5
927	55	-129	-110	-105	5
993	49	-130	-111	-105	6
1082	43	-131	-112	-105	7
1206	36	-132	-113	-105	8
1385	29	-133	-114	-105	9
1674	21	-134	-115	-107	8
2297	10	-137	-118	-112	6
2709	5	-139	-120	-115	5

4.4.3.1.2.2 Interference from Fixed Service to LEO Feeder Links

Fixed terrestrial microwave links share the Region 2 band of 18.8 to 19.7 with Fixed Satellite Services such as Iridium's feeder link to planned Gateway stations. Part 25 does not provide technical parameters in these bands for coordination between FIXED and FSS operating anywhere above 14.5 GHz. However, Appendix 28 does provide recommended technical parameters for coordinating separation distance at these frequencies considering both modes of possible propagation interference: Troposcatter and hydrometer scatter.

A sample calculation as detailed in Table 4.4.3.1.1-2 of Mode (1) (troposcatter) was performed for Climate Zone A (over land) using the Iridium gateway receiver parameters for elevation angle of 9 degrees and a "time invariant antenna". The coordination distance calculates to be 115 km for troposcatter and 75 km for Mode (2) hydrometer scatter. Because the Gateway could scan down to 9 degree on any radial, the coordination distance is a circle about the site location. However, insertion of the physical horizon will reduce the coordination distances for some radials. Part 25 allows reducing the earth station antenna gain to the horizon if it is a tracking system such as a LEO.

Table 4.4.3.1.2-2 Downlink Coordination Distance

Boltzsman _k	1.38E-23	(J/K)	Climate Zone_x	A	
Bandwidth BW	1.00E+06	(Hz)	Probability p	0.010	(%)
Freq	19.50	(GHz)			
			Rec Noise Te	731.00	(°K)
			Rec Noise pow	-139.96	(dBW)
			J (20% vs. thermal)	0.00	(dB)
			M(p)	5.00	(dB)
			W	0.00	(dB)
Pr(p) Max rec inter	-134.96	(dBW)			
			Interfer xmtr Pt	-10.00	dBW/MHz
			Delta gain delta_g	3.00	(dB)
			Interfer ant Gt	45.00	(dBi)
			Angle to Horiz Phi	9.00	(deg)
			Gain to Horiz Gr	5.14	(dBi)
Lb(p) Min link loss	175.11	(dB)			
			Freq Loss Ao	145.80	(dB)
			Horizon Angle e	0.00	(deg)
			Angle Correct factor Ah	0.00	(dB)
			Atmosphere Attn Rate	0.25	(dB/km)
Coordination Distance	115.91	(km)	Max/Min distance	WITHIN LIMITS	

The first use of this band by terrestrial microwave began about eight years ago, after the Commission adopted a new channel plan for the band. See Memorandum Opinion and Order in Gen. Docket Nos. 42-334 and 79-188, (Joint Reconsideration of First Report and Order in Docket No. 82-334 and Second Report and Order in Docket No. 79-188), released August 17, 1984, 49 Fed. Reg. 37760. The question of sharing the 17.7-19.7 GHz band between microwave and satellite users was raised when the channel plan was adopted, but was disposed of without providing any special treatment for satellite operations. Id. at para. 37-41.

The 18 GHz channel plan includes both point-to-point allocations and point-to-multipoint allocations. The bands 18142-18580 MHz, 18120-18920 MHz and 19160-19260 MHz are allocated for point-to-multipoint use, and the locations of receive sites are not included in any licensing or frequency coordination data base. Although the location of the sites are not known to the FCC, no doubt they are known to the system owners. In addition, locations of low power transmitters within the 18820-18870 and 19160-19210 MHz bands need not be specified; see Section 94.88 of the Commission's Rules.

The remainder of the 17.7-19.7 GHz band is used by terrestrial point-to-point microwave licensees. Typical path lengths are less than 10 km. Licensees operating on these frequencies include the County of San Bernardino, Dallas SMSA Limited Partnership, MCI Telecommunications Corp., US West New Vector, Denver Cellular Telephone Co., Bay Area Telecommunications, Inc. The band is used by cellular operators, by local bypass carriers, and by local governments.

Given the low power, short path lengths, and the narrow beams of these systems, it would seem quite possible to find a suitable location for a LEO Earth Station in or near the necessary urban areas. The exact locations can be coordinated with the users of the allocation and subsequently, the location of the LEO Earth Station made known to the users of the band.

Section 25.203(a) of the FCC rules includes the allocations of concern. Part 25.203(c) anticipates the necessary technical showings which will need to be carried out by an Earth Station applicant. Therefore no new rule is required.

4.4.3.1.3 Summary of Sharing in the 18.8-19.7 GHz Band

The 18.8-19.7 GHz band is allocated to the FSS on a co-Primary basis with the Fixed Service. The sharing analysis concerns LEO/GSO System and LEO/Fixed Service Sharing.

A. Sharing with the Fixed-Satellite Service

Techniques for LEO/GSO sharing are the same as those in the uplink case. There are two situations. The first situation (Case 4) includes use of band segmented frequencies, switching of a LEO Earth station receiver from one LEO transmitter to an alternate and acceptance of short term interference. In addition, the location of the LEO Earth Station can be geographically isolated with respect to the location of existing FSS stations to reduce the signal level into the FSS(GSO) receiver. For the second situation, (Case 3) the principal technique is to establish an area of geographic isolation.

B. Sharing with the Fixed Service

The Fixed Service is protected by PFD limits, and the LEO Earth Station is protected by separation distances, and coordination provisions in existing FCC rules.

4.4.3.2 Sharing in the 19.7-20.2 GHz band

4.4.3.2.1 Sharing with the Fixed Satellite Service(19.7-20.2 GHz)

4.4.3.2.1.1 Interference from LEO Satellites to FSS (GSO) Earth Stations

In this case, to prevent harmful interference from the ODYSSEY satellite transmissions into the FSS (GSO) Earth stations, several solutions are possible, as follows:

1. Ensure, if it is possible, that the ODYSSEY orbit ground tracks are such that the ODYSSEY satellite never passes through the beam of the FSS (GSO) Earth station, while the satellite is active. Because of the uncertainty in the location of the FSS (GSO) Earth stations, this may not be feasible to implement, particularly considering the corresponding measure proposed in section 4.4.2.2.1.1 (Item 1) above. This viability of this solution will depend on the specific nature of the FSS (GSO) network.

2. In the event that the alignment described in item 1 above cannot be avoided, interference may still be avoided by virtue of the narrow beamwidth of the ODYSSEY feeder link satellite antenna. The location of the ODYSSEY feeder link Earth station will determine where the satellite antenna must be pointed during the active service arc of the ODYSSEY satellite. This will prevent interference to FSS (GSO) Earth stations that are not located within the ODYSSEY feeder link satellite antenna footprint.

3. In the event that the possible alignment and co-coverage situations described in 1 and 2 above cannot be avoided, coordination to reduce or eliminate any harmful interference into the FSS (GSO) system, could be achieved by a combination of the control of power levels and the avoidance of co-frequency operation.

4.4.3.2.1.2 Interference from FSS (GSO) Satellites to LEO Earth Stations

In this case, to prevent harmful interference from the FSS (GSO) satellite transmissions into the ODYSSEY feeder link Earth stations, several solutions are possible, as follows:

1. Ensure, if it is possible, that the ODYSSEY orbit ground tracks are such that there is never a direct alignment between the FSS (GSO) Earth stations and the active ODYSSEY satellites. The current ODYSSEY orbit parameters result in such alignment situations occurring approximately every 6° along the GSO arc. Therefore this solution may be viable provided the use of common frequency bands by FSS (GSO) satellites is very low, as it is at present.

2. Locate the ODYSSEY feeder link Earth station outside of the coverage area of the FSS (GSO) satellite, and thus gain isolation due to the gain characteristics of the FSS (GSO) satellite antenna.

3. Coordinate with the FSS (GSO) systems such that the alignment does not produce harmful interference into the MSS feeder link. This could be achieved by a combination of the control of power levels and the avoidance of co-frequency operation.

4.4.3.2.2 Sharing with the Mobile-Satellite Service (19.7-20.2 GHz)

The concept of providing MSS at the frequency band is relatively new. Other than ACTS and NORSTAR-I, there are presently no other firm plans for systems. In the event that such systems do come into being, it is important to note that they will not benefit from the extra protection given to FSS GSO systems (RR 2613). Future MSS systems in this band could employ either GSO or LEO satellite constellations, and would need to coordinate with LEO systems.

4.4.3.2.2.1 Interference from Service Link Transmissions of MSS (LEO or GSO) Satellites to LEO Feeder Link Earth Stations

Interference from the MSS service link into the MSS feeder link will have to be coordinated, based on the specific orbit constellation characteristics of the MSS system which uses this band for its service link. The relatively narrow beamwidths of the MSS feeder link, both in terms of the satellite and Earth station antennas, will help in resolving any interference issues.